Series 540 Cartridge Tape Drive Product Description

cipher data products, inc.

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GENERAL DESCRIPTION

INTRODUCTION

The 540 is an innovative 1/4-inch cartridge tape product manufactured by Cipher Data Products, Inc. The 540 is built to the 5 1/4-inch form factor.

The 540 is a low-cost, high-performance streaming tape drive capable of storing up to 45 megabytes of (formatted) data on a standard 450-foot, 1/4-inch tape cartridge or up to 60 megabytes (formatted) on a 600-foot cartridge. The drive operates on +5 volts and +12 volts, and records data at up to 5.2 Mbytes per minute. The specifications for the 540 can be found in Section 5 of this module.

The 540 is available as a fully formatted drive. The 540 conforms to QIC-24, Revision D, Data Interchange Format Standard agreed upon by the industry and proposed by 1/4-inch cartridge tape drive manufacturers to the American National Standards Committee (ANSC).

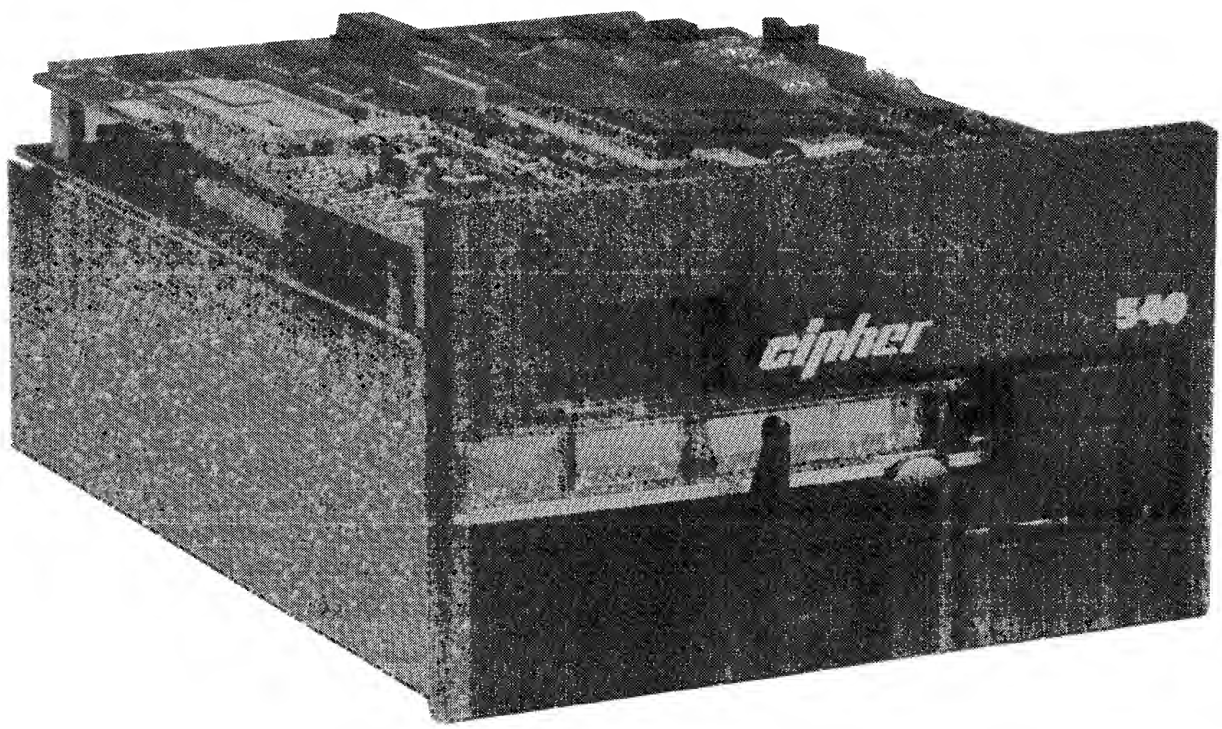


Figure 1. Cipher's 540 1/4-Inch Tape Drive.

The form factor is also standard. The 540 has a mounting structure identical to the industry standard 5 1/4-inch floppy disk or Winchester drives. The drive is designed for horizontal or vertical rack mounting to provide system integrators with maximum flexibility.

The 540 functions in a streaming mode. The advantages of tape streaming over conventional start/stop tape operation are simplified mechanics and a highly efficient use of the tape. Basic drive functions are microprocessor controlled and a second microprocessor, an integral part of the intelligent formatter, controls the overhead functions of tape formatting. This formatter microprocessor also provides the type of interface (QIC-02 or SCSI) which can be adapted easily to the requirements of most host systems.

Because of simplified streaming mechanics and the elimination of the long start/stop Inter-Record Gap lengths, the 540 is a low-cost, high capacity drive that is particularly well suited to backing up Winchester disks.

MECHANICAL DESCRIPTION

General

The 540 consists of these component parts:

- o Die-cast aluminum substructure
- o Unique cartridge loading and seating mechanism
- o Vertical head-positioning stepper motor
- o Bi-directional Read/Write head assembly
- o Separate full-width Erase bar mounted on the head
- o Brushless direct drive DC capstan motor
- o Beginning Of Tape (BOT)/End Of Tape (EOT) photosensing assembly with Write-Protect and Cartridge-In-Place sensing switches
- o Printed circuit board (pcb) with microprocessor control of basic drive operations
- o Microprocessor controlled formatter which provides QIC-24,Rev. D, formatting and QIC-02, Rev. D, or SCSI interfacing

Aluminum Substructure

The die-cast aluminum substructure provides the structural rigidity necessary to support the major mechanical assemblies. It also maintains the required mechanical tolerances to which the drive was designed. These tolerances are required to maintain the QIC-24 interchange specifications for track position and assure the interchangeability of cartridges.

Cartridge Loading & Seating Mechanism

The cartridge tray loading mechanism is activated by a front-mounted lever. Capable of a 90-degree rotation, the lever is moved to the vertical position to lock the cartridge in place. In the horizontal position, it allows removal or insertion of the cartridge. When the loaded cartridge and the tray are pressed gently back into the unit, the cartridge-protect door is opened. Then, when the cartridge and tray are pressed home, the lever can be rotated to the lock position. This causes the cartridge to be located by three registration point deck pins, per the ANSI specification. This procedure automatically seats and holds the cartridge in the best position relative to the Read/Write head and other pertinent assemblies.

Head-Positioning Motor

Head positioning to a formatter selected track is accomplished via the head positioning mechanism and associated driver electronics. Head gap to track positioning is within a 1/2-milli-inch tolerance to insure QIC-24 track height interchange.

Azmith and zenith tolerances are maintained through the use of a brass and stainless steel linear bearing that is an integral part of the head stepper mechanism. The drawing below illustrates the positioning mechanism.

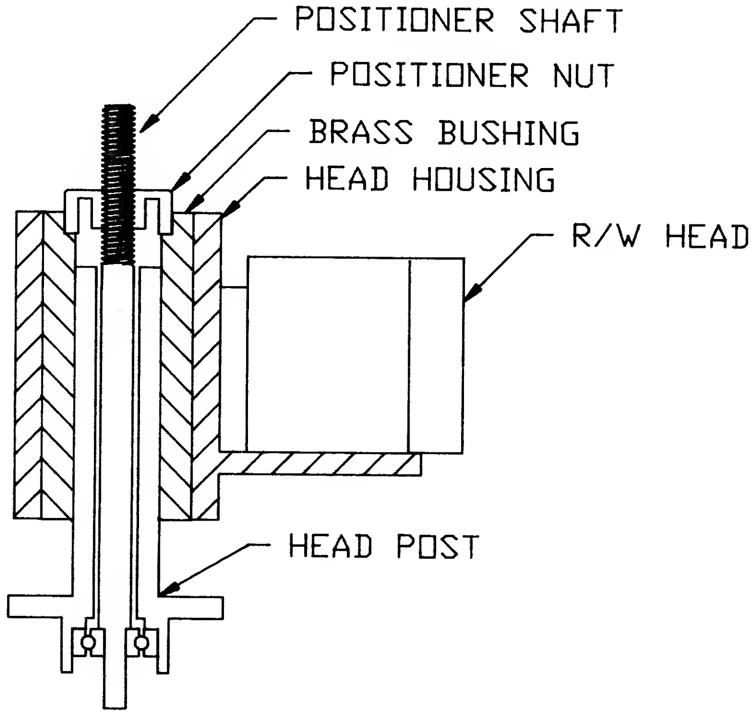


Figure 2. Head Positioning Mechanism.

Read/Write Heads

There are two Read head gaps to accommodate the bi-directional Read operation required for serpentine recording. In addition, there are two Write head gaps to accommodate bi-directional writing. One head gap records in the forward direction and the other records in the reverse direction. Tracks are recorded sequentially as shown in Figure 3. Even-numbered tracks are recorded forward and odd numbers in reverse, using the serpentine method. The head is composed of a hardened core material that results in a minimum head life of 2500 hours of tape motion.

Erase Bar

A full-width Erase bar is mounted on the head assembly. The erase operation is controlled separately and can be used when three conditions exist: (1) the unit is recording on track 0; (2) the cartridge is not on safe; and (3) the head is not being repositioned.

DC Capstan Motor

The tape is driven by a long-life brushless DC three-phase motor. The speed of the motor is controlled by a tachometer derived from three Hall-Effect motion position sensors. The motor, driving a 5/8-inch capstan, is capable of accelerating the tape cartridge to running speed in 300 ms.

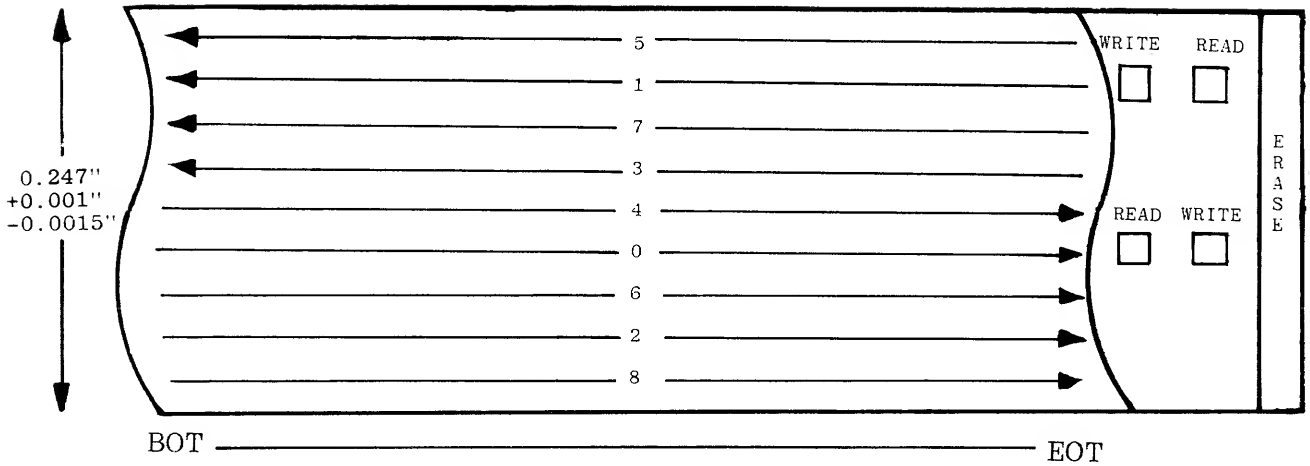


Figure 3. Tape Tracks With Read/Write Heads.

BOT/EOT Photosensing Assembly

This assembly senses holes punched through the tape. The sensing is accomplished by illuminating the back of the tape with a Light Emitting Diode (LED) and recognizing the light with two photo transistors.

Main Printed Circuit Board

The main pcb assembly performs:

- Tape speed control
- Head positioning control
- BOT/EOT detection
- Media sensing, write current/read gain switching
- Read/Write/Erase signal processing

An integrated microprocessor controls the tape direction, head positioning, and detection of the tape holes.

The main pcb provides the basic interface between the physical drive and the formatter control board.

Formatter Printed Circuit Board

The formatter is a pcb that fits inside the 540 form factor. It provides the QIC-24 block formatting, and QIC-02 or SCSI Interface.

The formatter board contains independent Read and Write control circuitry, data buffers, a host interface, a tape drive interface, and a microprocessor. The formatter performs three major functions by: (1) recognizing and formatting data written to, or read from, tape; (2) multiplexing data buffers; and (3) providing control and handshake signals for the QIC-02 or SCSI interface.

SECTION 2

BASIC DRIVE FUNCTIONAL DESCRIPTION

INTRODUCTION

The 540 drive functions in a streaming mode with a data density of 8,000 bits per inch (bpi). Recording is done in a bit serial recording format, using a serpentine stream configuration illustrated in Figure 4. This illustration, for the sake of clarity, shows only four tracks. The actual 9-track recording continues this sequential pattern.

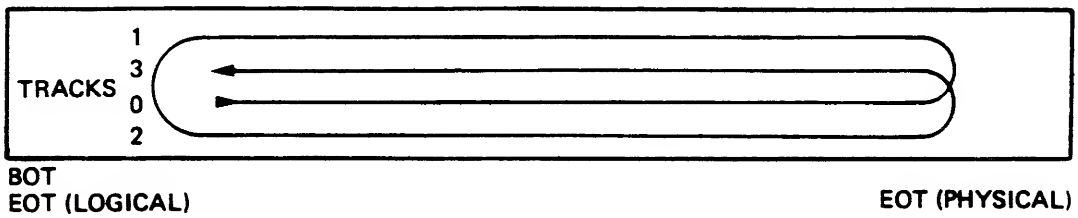


Figure 4. Serpentine Recording Format.

Data is encoded to (0,2) Run Length Limited (RLL) code and recorded at 10,000 flux changes per inch (fci) on the nine tracks. The streaming format provides constant tape motion and very short interblock gaps with minimal format overhead. This format maximizes data throughput efficiency. To take full advantage of the streaming format, the host system must maintain a constant data transfer rate, so the 540 is not forced to stop and reposition.

The advantages of streaming over the conventional start/stop operation can be explained most easily by tape use efficiency, which is the ratio of data record length to Inter-Record Gap (IRG) length, plus data record length.

In conventional start/stop drives, data is stored in records that can be accessed individually and updated. To preserve this update capability, the tape must stop and start between each record. This start/stop function requires the incorporation of a rather long IRG between the records. The length of these IRGs must be considered in the trade-offs of tape use efficiency versus data accessibility.

Although conventional drives provide sequential access to individual records, their tape use efficiency is typically low, because of the long IRGs. The ratio of record length to record length plus IRG can vary from 20 to 80 percent; but at 80 percent, the data record length is about four Kbytes, so the advantages of having short individual records are lost.

Tape use efficiency is also proportional to the tape drive data throughput rate; therefore, tape use efficiency is greater for applications that do not require updating of individual records.

In the 540, maximum tape use efficiency, which includes very short IRGs and constant-speed tape motion, can approach 100% and so, at 90 ips, a data throughput of

60 MB can be achieved in less than twelve (12) minutes.

TAPE CARTRIDGE DESCRIPTION

The 540 uses a 4 x 6-inch data recording cartridge that conforms to ANSI specifications X3.55-1977 and X3B5.82-89 for unrecorded cartridges. The cartridges are available in 450-foot (3M DC300XL, or equivalent) and 555-foot lengths, and 600-foot lengths.

The 1/4-inch wide magnetic tape is wound on two co-planar hubs. The hubs are driven by an internal drive belt which is coupled by an internal belt capstan. The capstan is driven by the 540 capstan roller and drive motor assembly. This configuration is illustrated in Figure 5.

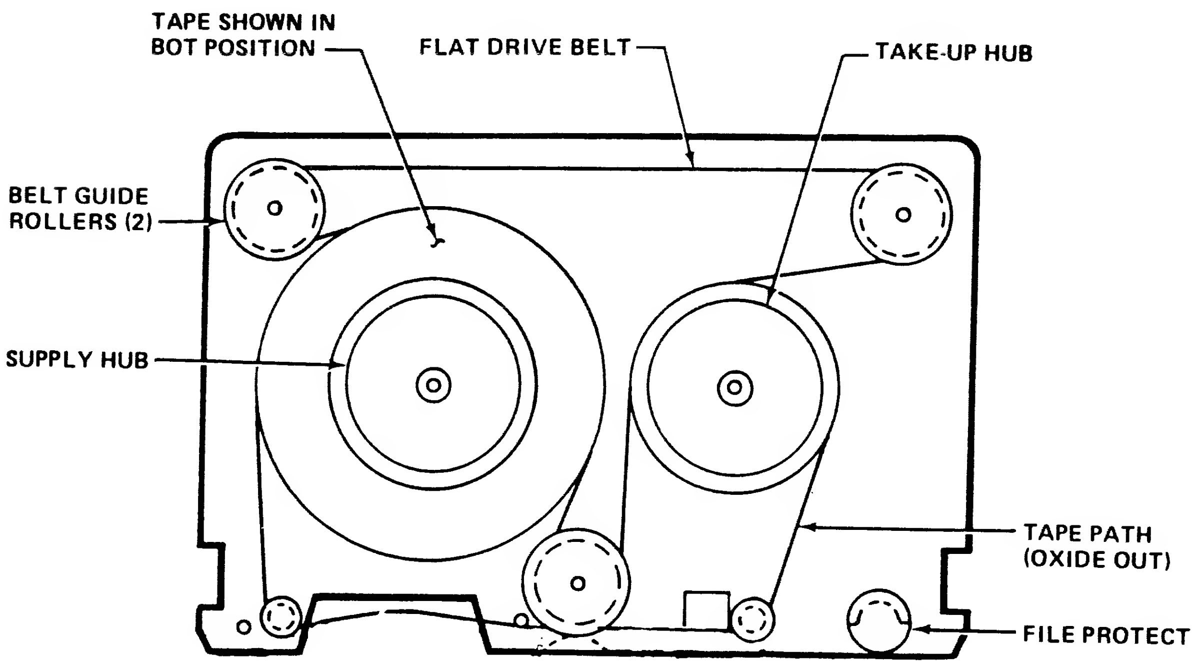


Figure 5. Tape Cartridge Configuration.

MAIN DRIVE PCB

The main pcb assembly performs these functions:

- o Tape speed control
- o Head positioning control
- o Media sensing - Write current/Read amplitude switching
- o Read/Write signal processing

Tape Speed Controlling

The speed of the tape drive motor is controlled by a tachometer derived from three Hall-Effect motor position sensors. The sensors are processed by a control Programmable Read-Only Memory (PROM) and routed to a frequency-to-voltage converter. The resulting voltage is compared to a nominal value. The integrated error signal is compared to a sawtooth waveform which then generates the pulse width modulation for motor control.

Media Sensing - Write Current/Read Gain Switching

Whenever the basic drive is told to "position" tape following a reset or a "new" cartridge is inserted, the basic drive will sense the media "type" and adjust its write/read circuitry to optimize recording/reading for that type of media. The two types of media are 310 Oersted or 550 Oersted. Examples of industry available media are:

- o DC300XLP= 310 Oersted
- o DC600A = 550 Oersted

The media "type" is sensed by the basic drive by counting the number of inches from the BOT hole to the Load point hole. The distances are:

- o 310 Oersted = 36 inches per ANSI
- o 550 Oersted = 48 inches per ANSI

The media type sensed indicates the coercivity of the media only, not the tape length.

Read/Write/Erase Signal

Separate Write and Erase controls are provided by a 34-pin interface between the formatter and the basic pcb. The Erase operation produces a full tape width AC field. Erasing is controlled by the formatter when recording is being done on Track 0 and during standard Erase command.

The Write operation is made bi-directional by using two Write head gaps. One head gap writes in the forward tape motion direction. The other head gap writes

in the reverse direction of the tape. The selected head gap is provided with +12V, regardless of the applied voltage. The selection is made by the TR0 signal provided by the formatter.

Two Read head gaps are provided to accommodate the bi-directional reading required for serpentine recording. The applicable Read head gap is also selected by the TR0 signal.

The dual head gap configuration allows the 540 to perform an internal Read-After-Write check during a Write operation.

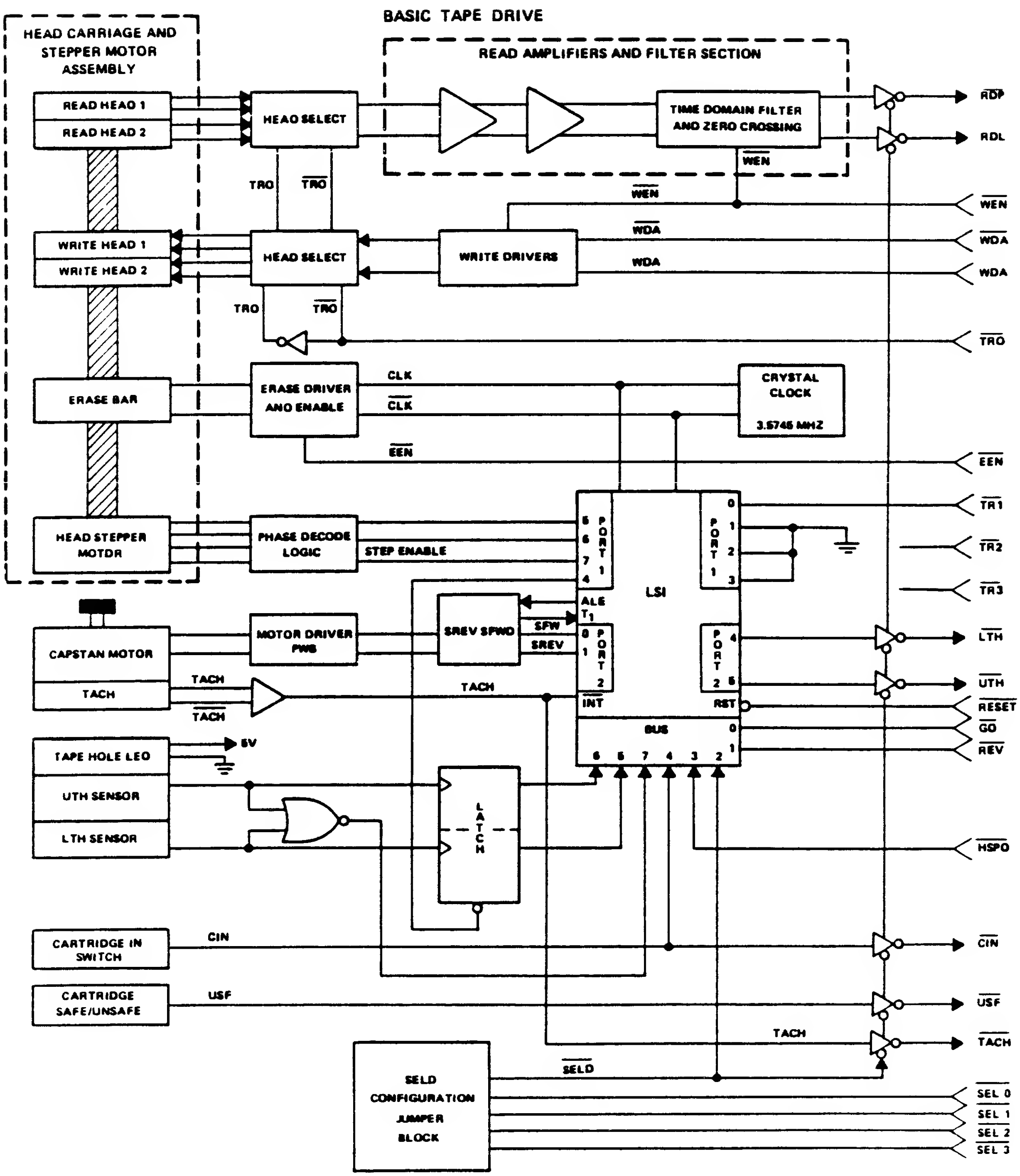


Figure 6. Basic Drive Diagram.

SECTION 3

RECORDING METHOD

INTRODUCTION

Although magnetic tape is an extremely reliable, cost-effective mass storage medium, even the highest quality tapes are subject to errors caused by small imperfections in the tape oxide coating. Sensitivity to these imperfections, usually a result of manufacturing error or repeated use, is proportional to the recording density. For this reason, the 540 uses the Non-Return-to Zero (NRZI) recording method to reduce sensitivity to tape imperfection through lower density recording. In the NRZI method, however, the normal 8-bit binary sequence can result in a data pattern with a large number of successive zeros. To preclude the need for Read circuits that require complex data-bit window functions, the 8-bit bytes from the host are converted to a 0,2 RLL code before being written on the tape. This code is reconverted to the NRZI code in subsequent Read operations. The RLL code provides a 10-bit serial stream with no more than two consecutive zeros in any data pattern. It also permits the data stream to be used to track the Read circuits to the data rate, so that speed variations between tape drives do not affect compatibility.

RECORDING FORMAT

The 540 data format is compatible to the Quarter Inch Committee's standard QIC-24, Revision D, and is a function of the formatter board. However both the QIC-02 and SCSI formatters use QIC-24 and therefore will be covered here.

The 540 does 9-track serpentine recording to cut the data transfer time. As shown previously in Figure 4, even-numbered tracks are recorded in the forward tape direction, odd-numbered tracks in the reverse tape direction.

All data for interchange is recorded in designated tape areas:

- o Even tracks - from Load Point (LP) marker to End Of Tape (EOT) marker.
- o Tracks 3 and 5 - from the Early Warning (EW) marker to the Beginning Of Tape (BOT) marker.
- o Tracks 1 and 7 - from the EW marker to the LP marker.

Tracks are recorded sequentially from 0 through 8.

DATA BLOCK FORMATTING

The data block is formatted as shown in Figure 7.

The preamble is used to synchronize the phase-lock loop in the Read electronics with the data frequency. The preamble is also used to measure the average preamble amplitude. There are three preamble lengths, measured by a range of flux transitions per inch (fti). These preambles lengths are:

- o Normal (120 to 300 flux transitions).
- o Elongated (3,500 to 7,000 flux transitions). This preamble precedes the first data block recorded after an underrun.
- o Long (15,000 to 30,000 flux transitions). This preamble precedes the first data block for interchange, recorded at the beginning of track 0.

The data block marker identifies the start of the data block.

Preamble	1 Byte	512 Data Bytes	4 Byte Block Address	2 CRC Bytes	Postamble

Figure 7. Data Block Recording Format.

The data block contains 512 bytes of data for interchange. The data is encoded according to the 0,2 RLL transformation table. (A filemark block has a format identical to the data block, except the data field contains a unique pattern which does not occur in a data block.)

The block address contains four bytes that provide a unique identification for the data block recorded on tape. This address includes:

- o The 8-bit track number in byte 0.
- o A 4-bit control block in byte 2 that defines the contents of the data block as being user data or file mark (0), control information (1), or reserved (2-15).

  QIC-24 control blocks are not implemented on the 540.
- o The 20-bit block address in the other four bits of byte 1, plus bytes 2 and 3. Block addresses are not reset at the end of a track.

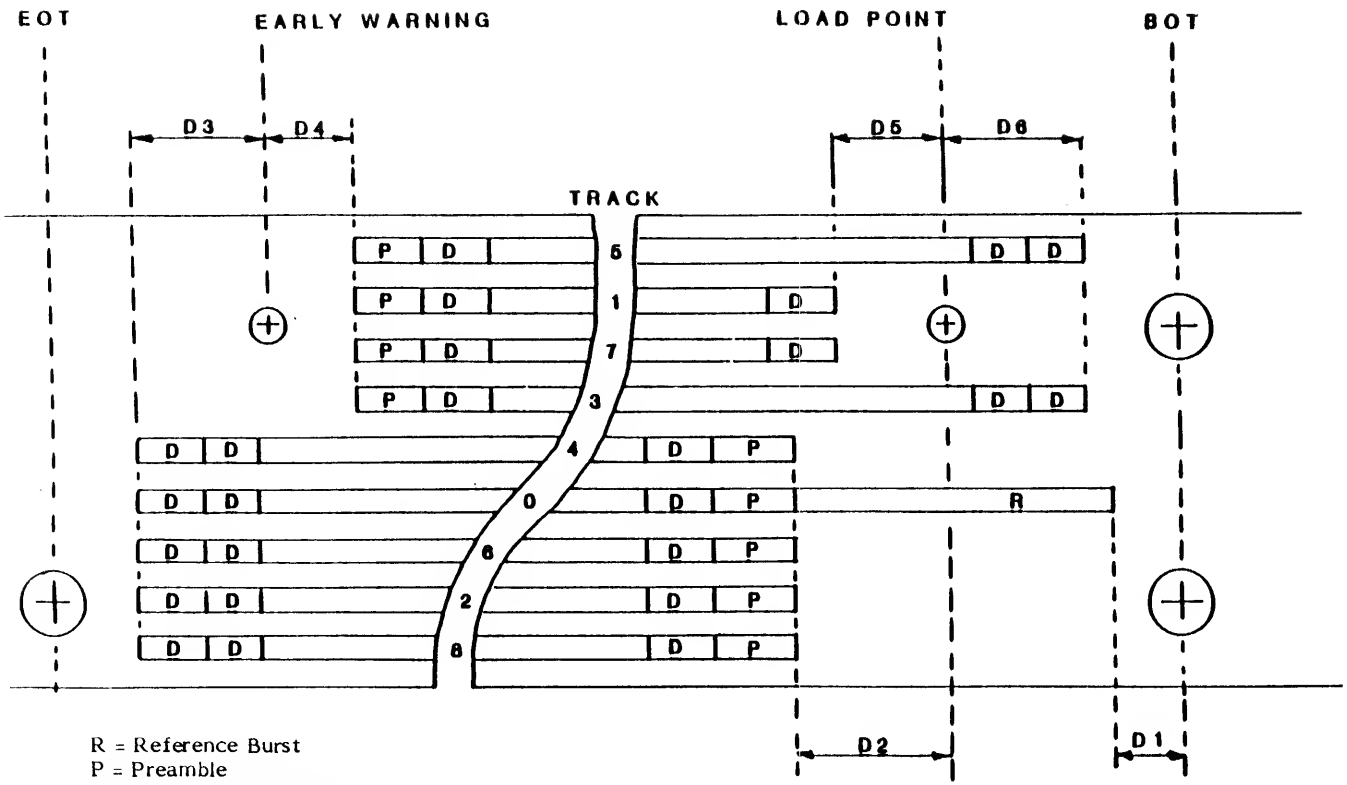
See Figure 8 for QIC-24 format parameters.

CYCLIC REDUNDANCY CHECK

The Cyclic Redundancy Check (CRC) consists of two bytes calculated over the 512 bytes of interchange data and the 4-byte block address. CRC starts with an initial value which is all ones and uses this CRC generating polynomial:

$$X^{16} + X^{12} + X^5 + 1$$

The CRC is encoded using the 0,2 RLL transformation table.



R = Reference Burst
P = Preamble
D = Data or Control Block

Dimension	Min (in)	Max (in)	Description
D1	0	15	BOT to start of track reference burst
D2	3	4	Load point to end of track reference burst and start of preamble on even tracks
D3	-	36	Early warning to end of data on even tracks
D4	1	2	Early warning to start of preamble on odd tracks
D5	0.1	4	End of data to load point on Tracks 1 and 7
D6	-	27	Load point to end of data on Tracks 3 and 5

Figure 8. QIC-24 Format Parameters.

The postamble is recorded after the CRC and serves as a guard band. The postamble can have two lengths:

- o Normal, which is 20 flux transitions at the maximum nominal flux density.
- o Elongated (3,500 to 7,000 flux transitions) recorded at maximum nominal flux density following an under run sequence.

BLOCK REWRITING

If all requirements for a data interchange are not met, the data and filemark blocks are rewritten and tested again by the Read-After-Write operation. The sequence reads block N while block N+1 is being written. If block N does not satisfy the requirements, it is rewritten after the writing of N+1 is completed. If N is now satisfactory, N+1 is also rewritten to preserve the correct sequence. A Block In Error (BIE) is written up to 16 times before the recording operation is aborted.

Block rewriting also occurs when an underrun, End Of File(EOF), or End Of Tape (EOT) terminates the streaming operation. In these cases, block N is rewritten until all the interchange requirements are met. Then after block N is properly recorded, an elongated postamble is written starting at 3,000 flux transitions from the end of the previous block. An elongated preamble is recorded for the next block (N+1).

Termination by an underrun can be prevented by the repeated recording of block N until an EOF or EOT occurs. This forced streaming operation uses only standard length format fields.

SECTION 4

INSTALLATION and MAINTENANCE

INTRODUCTION

This Section describes the required physical mounting of the 540, ambient conditions for operating the drives, cartridge loading and unloading, and recommended methods of cleaning the drives.

MOUNTING THE DRIVE

The 540 can be mounted horizontally or vertically, but not in an upright (on end) position. When mounted horizontally, the electronic circuit board must be on top.

Figures 9 through 12 illustrate the 540. Four 6-32 tapped mounting holes are provided on the base of the drive to secure it to the complementary surface of the cabinet, rack, or other enclosure. For alternative mounting, two 6-32 tapped mounting holes are provided on each side surface of the drive. If side mounting is required, all four mounting holes must be used. The mounting screws should not penetrate the surface by more than 0.22-inch (0.56 cm) or less than 0.125-inch D(0.318 cm).

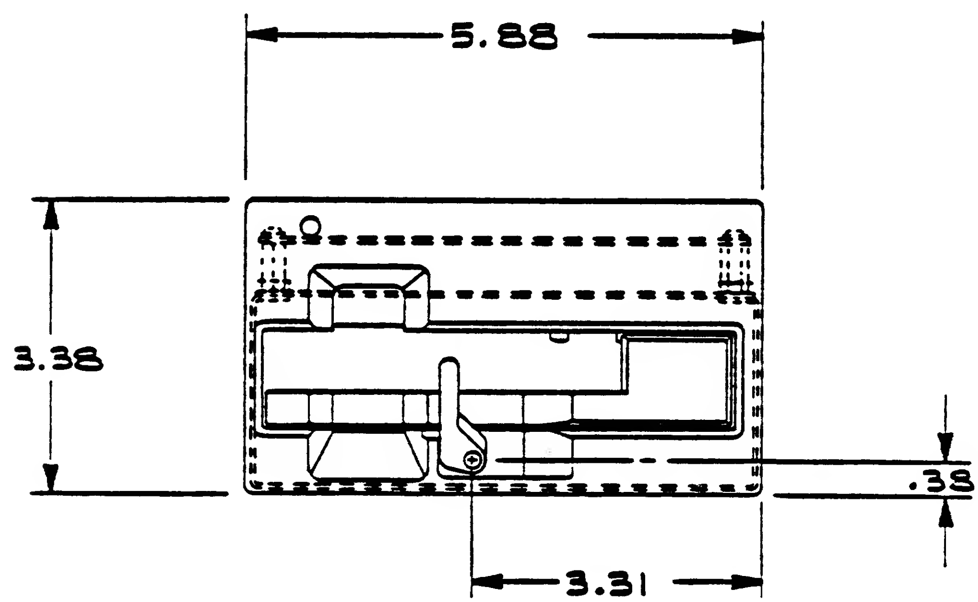


Figure 9. Front View of the 540.

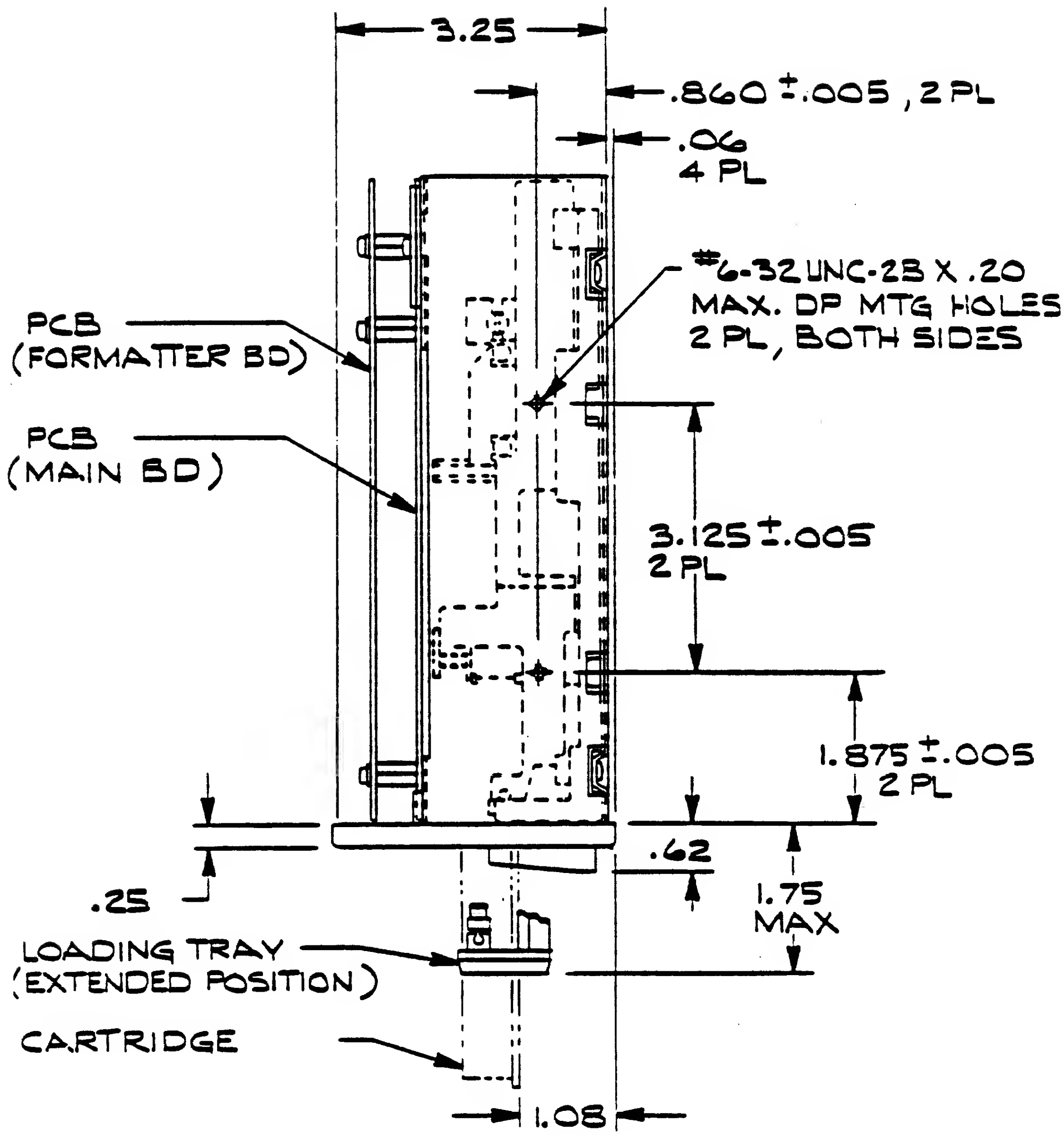


Figure 10. Right Hand Side View of the 540.

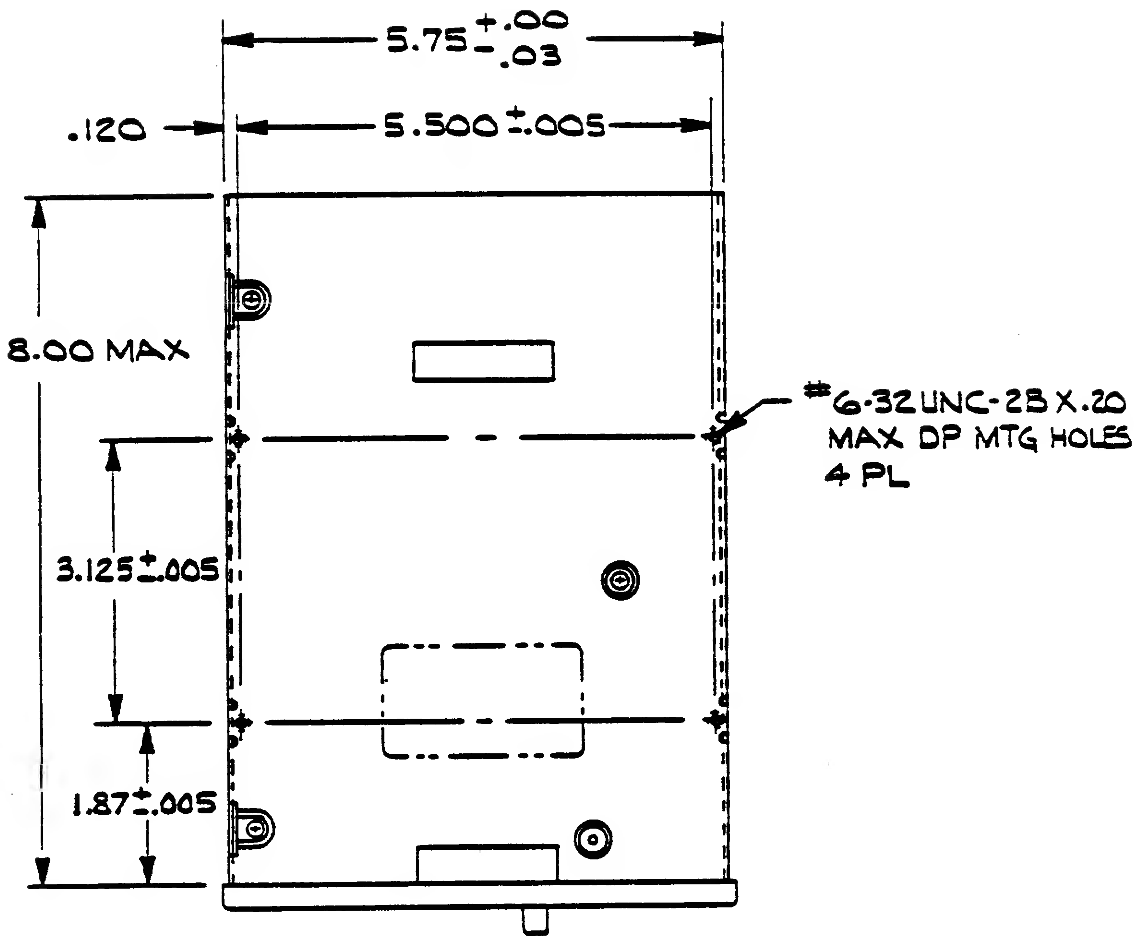


Figure 11. Bottom View of the 540.

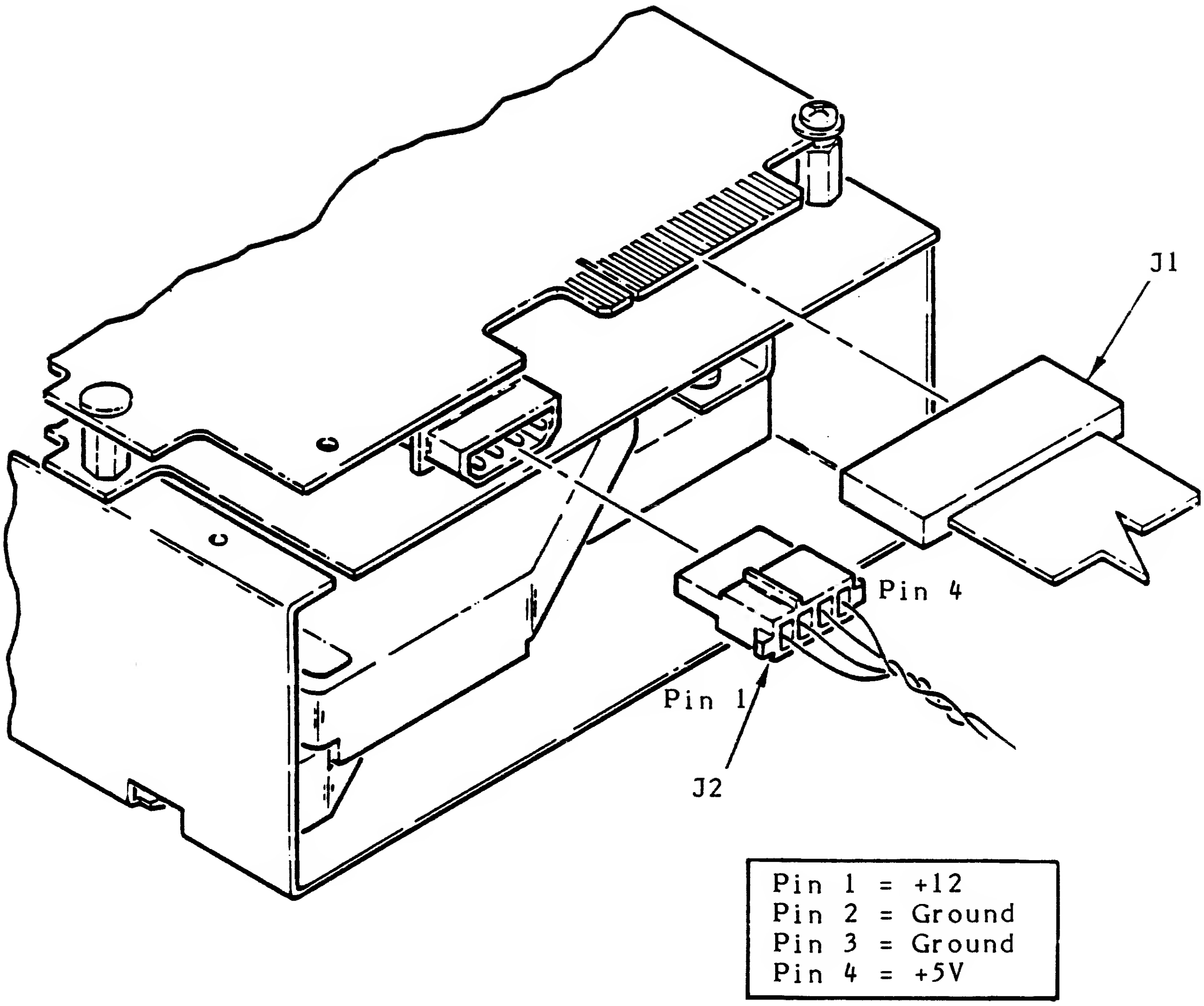


Figure 12. Partial View of the 540.

Operating Temperature

A free air flow is required around the tape drive to prevent the ambient operating temperature of the drive from rising above 113°F (45°C). If this maximum ambient operating temperature cannot be maintained, forced air cooling should be used in the environment to maintain the cartridge base plate at or below the specified maximum operating temperature of 45°C.

CARTRIDGE LOADING/UNLOADING

The cartridge tray loading mechanism is actuated by a front-mounted lever. This lever can be manually rotated a full 90 degrees. In the vertical position, the lever locks the inserted cartridge in the operational position. When the lever is horizontal, the cartridge tray is released and ready for cartridge insertion or removal.

As shown in Figure 13, the cartridge is loaded by inserting it into the tray and pushing it into the drive until it reaches the rear edge of the tray. This action automatically aligns the outer edge of the cartridge with the front of the tray. With a continuing push, the tray and cartridge moves to the rear stop automatically opening the cartridge-protect door. Once the cartridge is fully inserted, it is automatically locked in place and seated correctly, relative to the Read/Write head.

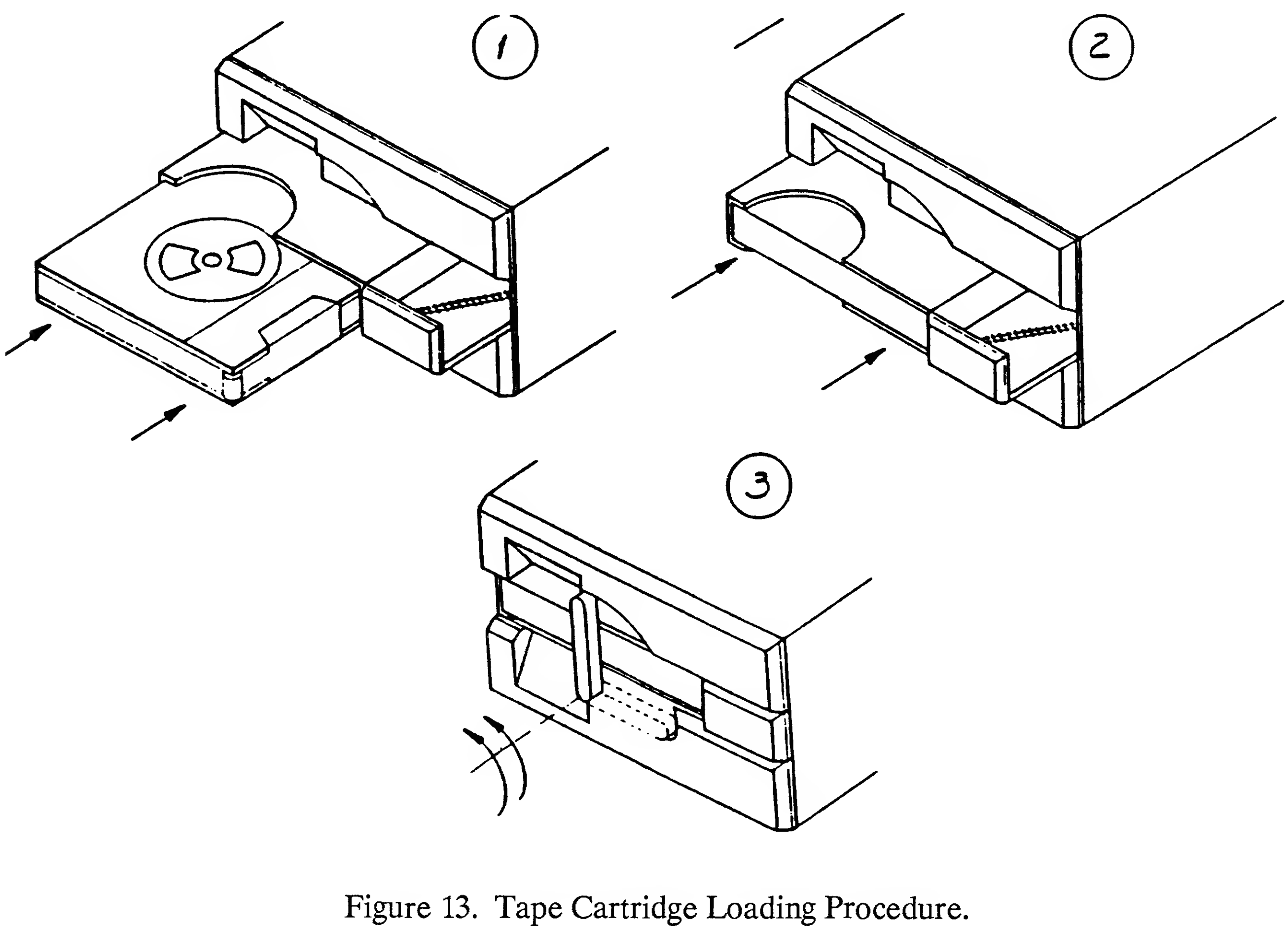


Figure 13. Tape Cartridge Loading Procedure.

The cartridge is unloaded by moving the lever to the horizontal position.

CLEANING THE HEADS

The Read/Write heads may be cleaned using the Cipher 1/4" Cartridge Head Cleaning Kit, Part No. 942191-001. Replacement cleaning elements can be obtained by ordering Part No. 942192-001 as needed.

The Read/Write heads can also be swabbed gently with a lint-free swab moistened with Freon TF.

After the heads have been cleaned, they should be allowed to dry thoroughly before the unit is used. It is not usually necessary to clean the heads more than once every 20 hours of actual tape movement.

NOTE

Head cleaning should only be done when the drive power is off.

SECTION 5

BASIC DRIVE SPECIFICATIONS

INTRODUCTION

The applicable specifications have been ascertained using a cartridge certified by Cipher in a 540 with a formatter pcb.

In the specifications for errors, it is understood that a recoverable error is one that can be overcome in no more than 16 retries.

Data Handling	
Capacity (formatted)	
450-ft Cartridge	45 mb
555-ft Cartridge	55 mb
600-ft Cartridge	60 mb
Recording Tracks	9
Data Density	8,000 bpi
Transfer Rates	
90 ips	86.7 kbs (sustained)
Recording Form	9-track, serpentine
Recording Code	(0,2) Run Length Limited
Head Type	2-channel Read-After-Write with full-width AC Erase Bar
Maximum Error Rate:*	
Soft Write	1×10^7
Soft Read	1×10^8
Hard Read	1×10^{10}
Mean Time Between Failures	18,000 hour with 20% workload

*Soft errors recoverable in 16, or fewer, tries

Power Requirements

DC Voltage		
Control	+12V ± 0.6	
Logic	+5V ± 0.25	
Maximum P-P Ripple (included in tolerance)	+12V: 200MV +5V: 50 MV	
Current Requirements	+5V	+12V
Standby Current	1.0 Amps	200 MA
Operating Current	2.2 Amps	1.8 Amps
Maximum Motor Startup Surge	2.6 A for 350 ms at +12V	
Power Dissipation		
Normal	30 Watts	
Surge	42 Watts	
Heat Dissipation		
Normal	66 BTU/hr (approx.)	
Maximum	143 BTU/hr (approx.)	

Dimensions & Weights

The hole spacing for the rack mounting is the same as a standard disk drive having the equivalent form factor.

Height	3.38 inches (8.59 cm)
Width	5.88 inches (14.94 cm)
Depth	8 inches (20.32 cm)
Weight	4.5 lbs (2.04 kg)
Maximum Shipping Weight	5 lbs (2.27 kg)

Environmental Requirements	
Temperature Range	
Operating	+5°C to +45°C (+41°F to +113°F)
Non-Operating	-30°C to +60°C (-22°F to +140°F)
Relative Humidity*	
Operating	20 to 80%, non-condensing
Non-Operating	1 to 90%, non-condensing
*at 26°C max, wet bulb (tape cartridge specification)	
Altitude	
Operating	Sea level to 10,000 feet (3 km)
Non-Operating	Sea level to 49,000 feet (15 km)
Temperature Gradient	
Operating	1°C minute maximum
Shock (1/2 sine, 10 ms long)	
Operating	2.5 G, 1/2 sine wave, 11 ms
Non-Operating	30 G*
*Shipping and short term storage (in Cipher shipping container which meets NSTA specifications).	
Maximum Acoustic Output	
Open Frame	55 dba at one meter
Vibration	
Frequency Range	5 to 500 Hz
Peak Acceleration	1 G
Application	3 orthogonal axes

SECTION 6

INTERFACE

Interface splecifications for the 540 tape drive are available for this manual from Cipher in Addendum form. They are:

QIC-02 INTERFACE ADDENDUM

Manual no. 799905-005

SCSI-1 INTERFACE ADDENDUM

Manual No. 799906-001

SCSI-2 INTERFACE ADDENDUM

Manual No. 799906-002

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Revision A
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